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REPORT ON CERTAIN LANDS

LEASED FOR

OIL AND GAS

NEAR CANNEL CITY, MORGAN COUNTY, KENTUCKY

BY ALFRED C. LANE

LANSING, 1902.

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J. H. Morgan, Esq., Lexington, Ky.:

SIR—I beg leave to submit the following report on the lands you requested me to examine:

AUTHORITIES.

In matters of ownership I have depended entirely upon the representations of my guide, ex-Sheriff Wheeler, of the county. I have also followed his usage in the matter of names of minor creeks, though, as the region has been topographically mapped by the U. S. Geological Survey, the important names are given thereon. It is included in their Salyersville quadrangle (Lat. 37° 30′ to 38°, Long. 83° 00′ to 83° 30′). I have also used the geological maps of the Kentucky Geological Survey, and other state maps. Finally I have to express especial obligations to Prof. Arthur M. Miller, of the State College.

GENERAL RELATIONS.

The area in question lies, as will be seen by the map sent you, or any geological map of the United States, on the eastern flank of the blue grass region, which is produced by a very broad but gentle uplift of the rocks known as the Cincinnati anticline. This extends from Tennessee clear through Kentucky and Ohio, and even up into Michigan and Canada. Between it and the sharper narrower folds and great disturbances of the Appalachians is the long area of the great Appalachian coal field. This trough is somewhat affected by minor disturbances which may be likened to dying out waves of the Appalachian system. Wherever these produce upward bends of porous beds, such as coarse sandstone, granular limestone or dolomite, or fissured limestone, covered by a sufficient thickness of impervious clay shales, we are likely to have along the crests valuable collections of oil or gas. Northeast of your property, in the direction of the strike of the rocks, oil and gas fields, well known and too numerous to mention, occur in West Virginia. The nearest producing field is, however, to the northwest, at Raglands, in the southeast corner of Bath county. To the south is the Knox county field, and to the southwest is the Wayne county field. Your leases are thus surrounded, and the *land in Morgan county is then without any doubt in an oil producing area and underlain by oil bearing strata.*

The main question left to consider is whether the local conditions are such as to favor the collection of oil in large and commercial quantities.

The next section being a description of my trip and observations, may be skipped by any one who has not especial geological interest, as the results will be given in the succeeding section.

DETAILED ACCOUNT OF TRIP.

Lexington to Caney:

Leaving Lexington we proceed on the L. and E., formerly Kentucky Union R. R., east over the rich rolling blue grass lands characteristic of the thin bedded phosphatic blue limestones of the Hudson or Cincinnati group, to Winchester and beyond. Then passing over a curious flat region at Indian Old Fields, and successively the outcrops of the heavily bedded Clinton dolomite, the Niagara shale (Rochester shale), which is some 40 feet thick, and the Corniferous, which is well marked though only a few feet thick, we come along the Lulbegrud creek to a knobby region, the knobs being composed of the Devonian black shale, with more or less of the overlying Waverly silicious green shales. At Clay city we strike the broad valley of Red river, which however rapidly narrows as we find the hard beds of the Subcarboniferous limestone on the walls of the valley and very soon after separated from the limestone only by the 40 feet or so of Pennington shale the overhanging ledges of the fitly named Rockcastle Conglomerate. These are well exposed at Natural Bridge, and Torrent, where we pass through a tunnel, and into the valley of Walker creek, a short creek which drains directly into the Kentucky river. Before we come to Torrent in the valley of the Middle Fork of Red river we pass a slight disturbance, which Prof. Miller tells me is a fault that can be traced from Estill Springs, and may continue to the Morgan county anticline which we are to visit. From Torrent down to the Kentucky river we are in the coal measures of the Lee formation, and signs of coal are frequent. Where we strike the Kentucky river it looks as though there might be a break, for a sandstone quite conspicuous on the south side of the river is apparently wanting on the north.

Thence to Jackson we go through a series of sandstones, shales and coal seams, which vary so much and yet are so alike that they cannot be followed out in a railroad journey. At Jackson, just back of the station on the west side of the river, the main part of the town is on the east, about 35 feet above the track is the tipple of a coal mine, the exposures of the seam and drifts of which are in the valley to the east. The dip of the coal seam appears to be southwest, locally, but going to the northwest across the neck of the great bend which occurs here, we find under the coal seam fifteen feet, a smaller six inch seam of coal, which passes over a heavy sandstone, which also tends to rise. Following the Kentucky river along the tracks of the Ohio and Kentucky R. R., which runs at present from Jackson to Cannel City, I think we can keep track of this sandstone or horizon down to the hills back of Frozen creek.

Frozen Creek:

There are two feet of coal exposed in the cut-off of a long bend in the river which the railroad makes just before, and also along the track for a mile up stream, at an elevation of about 720 A. T. Back of the station from 855 to 895 A. T., is a heavy sandstone, and again between 830 and 875 A. T., and the top of the hill is about 1,080 A. T. Nowhere in the section were characteristic fossils or limestones observed, or anything but Stigmaria and similar species common everywhere in the coal measures.

The railroad goes up the creek, crosses through a tunnel to the

Rose fork of Red river, which it follows down to State Road fork, which it follows up until it crosses over to the head waters of the Caney and stops at Cannel City. Here the railroads themselves have extensive mines of a cannel coal which is shipped to Lexington and beyond, and Mr. Rittenhouse is said to have a mine which is even thicker. It is said to run about 7% of ash and 48% volatile combustible, and from 22 inches to 7 feet thick. About 40 inches above is a bed with small pebbles of iron carbonate. A very similar bed may be noticed over on Stacey fork, where the beds dip to the north as here to the south. There are said to be two seams of cannel coal around here. I saw but one. A well for water is also said to have been put down 380 feet, and to have been in rock similar to that encountered by Sullivan's well at 100 feet, but that is rather more of a dip than I should expect, from the surface indications, though I have used it in drawing my section. As it is fresh water, and I heard nothing of gas or oil, it is probable that at that horizon nothing can be expected from the anticlinal, that far from the crest. Hoeing and Sullivan have already found gas in less than 100 feet.

Around Caney:

Leaving Caney, where the cannel coal is perhaps 90 feet above the valley floor, and dips distinctly off toward Cannel City (S. 50° W.) we come in about a quarter of a mile due north to where Hoeing and Sullivan are drilling a well. This is near the crest of the anticlinal, and at the time of our visit, March 30th, they were down about 100 feet and had already struck gas enough to run their boiler. The rock drilled appeared to be all the way a clear glass sand, but Mr. Sullivan informed us that there were really some small quartz pebbles and that it cut the drill quite fast. It is probably either the Corbin sandstone, as Prof. Miller was inclined to believe, or as drawn in the section, the Rockcastle conglomerate, brought near to the surface by the up fold of the anticlinal. No noteworthy exposures were noted until about 1.5 miles from Caney where a branch comes in from the west. Here a sandstone which lies not far above the cannel coal, and has been high above the valley floor on the hills near the center of the anticlinal comes down to the level of the side valley (exposure a) and is found to be dipping 6° toward N. 34° W. In a short distance it has fallen to the level of the main creek, and a quarter of a mile north of the forks of the road where a road turns to the northeast to go over to the Vance fork of White Oak creek, an extensive bluff of coal measures is exposed (b) with a dip of more than 8° to 10° toward N. 34° W.

Returning to the forks mentioned and turning to the east over the hill we find the sandstone again, coming in 160 feet or more above its exposure in the valley and capping the summit of the hill (1,100 feet A. T.). As we descend into the valley of the Vance fork to the northeast, the sandstone may be seen dipping to the northward (270 feet in less than a mile) from a knob on the south.

This knob Mr. Wheeler told me was owned by an old lady who was afraid to lease to any one. The valley is so nearly along the strike and deepens so rapidly, that we are soon below the sandstone once more and into the dark flags beneath. Not far below comes a coal seam which is frequently worked. The flags dip steeply toward N. 21° W. (Exposure d). Finally as we go down the branch (lease 33) the sandstone

comes down to water level and the stream flows over northward dipping sandy ledges. Near the mouth of Vance fork where the Prater prong comes in from the north (leases 34 and 35) we find a bed of limestone overlying it and quite rich in marine fossils; Chonetes, Pelecypods, Spirifers, Orthoceras, etc., which have been referred to Dr. Schuchert for identification. There is still a decided dip to N. 15° W., and the swing of the dip suggests that we are approaching the northeast end of the anticlinal. Going down the creek 500 feet beyond where the Vance fork meets the main right fork of Whiteoak, we find an extensive exposure, still dipping 5° to 10°, with black shales and coal in the stream and 50 to 100 feet of flags passing into heavier sandstone above.

Going back and up the right fork of Whiteoak creek, the beds continue to rise rapidly and we cross the limestone and sandstone again, which may be seen rising on the east side of the valley. Up to where the road turns rather sharply west (exposure e), that is about one mile, the beds continue to rise slightly. Above this, up to Wm. Vance's house, which appears to be near the center of the anticlinal, there is practically no dip, the exposures of coal measure shales being nearly horizontal. At this point and for some distance up stream the dips and exposures are complicated by some extensive side hill slip faults, due to blocks of the strata working down hill. One of them strikes nearly north and south. The dips may appear flat on the east side of the stream and southwesterly on the other. By the time we come to S. L. Reed's house, however (lease 44), there is a distinct but gentle dip up stream, three feet in 200 or so. The upper sandstone with 26 inches of coal under it comes down. This is close to the place where the road forks, the left fork going over the hill to the main Whiteoak, and the right, which we follow, returning to Caney.

We follow a creek but rise rapidly and soon are above the upper sandstone which crosses to the north of us rising toward the center of the anticlinal, and the road does not cut down through it again until close to Caney, where we find it on the roads east and south of town less than a mile. Thence going from Caney toward Cannel City, the end of the O. & K. R. R. and turning sharply to the northwest, just as one enters town, we are now nearly on the line of the section I have drawn. This road to Stacey fork rises to the upper sandstone close above the coal, which here is not more than perhaps 20 to 40 feet above the valley floor. It remains on it, passing over the crest of the anticlinal, until well down into Mud-Lick fork of Stacey (Steve Jeredore's), from which point all the way down the creek the northwest dips are decided. On lease 10 we note a dip of 10° to N. 36° to 30° W. The series is the usual one of shales, coal and sandstone. Turning up the main fork of Stacey we find the beds and dips well shown especially well near the dam, and the dip seems to continue to the northward up to leases 2 and 3, where it is practically flat, while on lease 1 a dip to the south at last appears. I am informed that on Grassy creek the disturbance is much less pronounced, but I wonder if the creek valley is not too far north to show it up well. It looks as though the crest of the anticlinal passed along the divide south of Sellars toward Red river. Prof. Miller connects it with the disturbance at Torrent. Northeast, too, toward Matthew it is said to disappear rapidly, though it is so strong on the Right fork of Whiteoak that I should expect to see something of it on the main creek. The breadth of the anticlinal is certainly over a mile on each side of the

crest, the abnormal northwest dips being marked for over two miles, down below where the Stacey fork flows into Caney. The length of the crest which I actually traced was over five miles, and a mile more it is safe to infer. The strike is not far from N. 65° E. The corresponding northwestward direction of dip would be N. 26° W., which is exactly the average of the northwesterly dips above noted.

The total area of your leases as described to me, platted on the map, and estimated by planimeter is 8,500 acres. They surround on three sides the area of 1,600 to 2,600 acres close to Caney, leased by Hoeing and Sullivan. I estimate, however, that your leases cover over four miles of the crest of the anticlinal, with both flanks of it on the right fork of Whiteoak, and the northwest and a little of the southeast on Stacey. The productive belt is usually from a quarter of a mile to a mile wide on either side of the crest of the anticlinal. I estimate that roughly 1,250 acres* of above land are within one-quarter mile of the crest, and are as promising for the production of oil or gas as any land can possibly be that has not been proven by the drill.

Applying the estimate of State Geologist I. C. White of West Virginia† that developed oil lands will on an average produce 5,000 barrels an acre (of 42 gallons), and assuming a profit per barrel of 50 cents net,‡ we should have $6,250,000 worth of oil, the production of which will of course be spread over a term of thirty or forty years or more. In this calculation I have taken the area of productive territory much narrower than it is likely to be, and all the other figures are well within limits, so that if a productive oil field is struck at all the figures given are very safe. The most important uncertainty relates as to whether the oil or gas will be struck, and in what proportions. For gas will involve

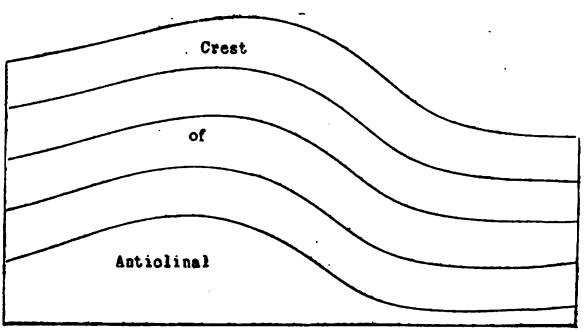


Fig. 1. Section of unsymmetrical anticlinal, showing shifting of crest.

a much larger expense to make it available, since the area is about 125 miles as the crow flies from Cincinnati and part of the way very rough. It is quite probable that wells on the extreme crest will find gas while on the flanks oil will be struck. The northern side of the anticlinal is the steeper, and as a glance at the figure above shows the position of the

* 455 north of crest on Right Fork of Whiteoak, 426 south, 284 north on Stacey and 90 south.

† W. Va. reports, Vol. I, p. 156.

‡ It is quite as likely to be 70 cents or more, and will depend on the quality of the oil which will probably run in value from 80 cents a barrel to $1.30, but something must be allowed for distance from market.

crest of the anticlinal will be shifted somewhat, the more the deeper the oil sand.

The probable column at the center of the anticlinal I give in the next section.

This leads to the consideration of the different oil sands and their depth.

Prof. Miller gives the following table of formations:

	Feet.	Total.
CARBONIFEROUS:		
Breathittformation	500	500
Corbin sandstone lentil (oil?)	150	650
Leeformation	500	1,150
Rockcastle lentil	150	1,300
SUBCARBONIFEROUS:		
Pennington shale	40	1,340
St. Louis Limestone	150	1,490
Waverly sandstone and shale	350	1,840
DEVONIAN:		
Black shale	200	2,040
SILURIAN:		
Niagara shale	50	2,090
Clinton magnesian limestone	30	2,130
Hudson limestone, to top of Trenton	600	2,720

It is easy to see that the section I have drawn does not agree with this, but his qualifications must be noted,—that he gives the maximum thicknesses, and that depths will be less the nearer the wells are to the axis of the anticline.

Thus his figures are maximum figures, which it will be safe to use, so as not to be too soon discouraged, but my section is constructed, using observed outcrops and data, to give the most probable figures. Those actually found may be greater or less.

Hoeing and Sullivan seem to be starting into a heavy sandstone which is likely to be either the Corbin or Rockcastle sandstone. But allowing for the dip which the observations around the Bath county fields indicate, or which may be inferred from the breadth and thickness of the outcrops on the geological maps, and also for the breadth, extent and steep dips of the anticlinal, to say nothing of a flat belt to the north, and the general flattening of dips in the trough, it becomes difficult to imagine that the Corbin is as low as the base of the anticline. I do not find topographic signs of its escarpment where it should be expected, if such were the case. If, as I imagine and as the section shows the sandstone which Sullivan is entering is the Rockcastle, then we have one possible oil horizon taken off the top of the section, and about 1,100 feet with it, at the center of the anticlinal. In compensation the Bath county oil horizon is brought that much nearer the surface and the Trenton within easy striking distance. Thus the oil prospects are much the same in either case.

Bath County Oil Field:

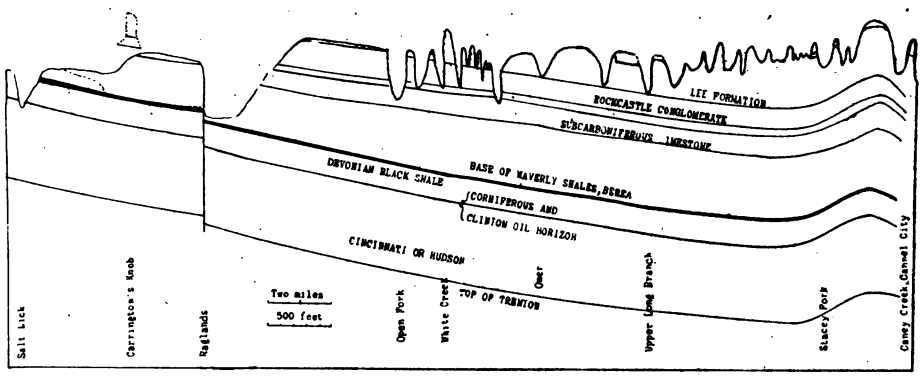
Immediately above and back of the station of Salt Lick on the C. & O. Railroad, which is about 650 feet A. T.,* the hill rises to 915 feet A. T. The rock at the base of the hill is not exposed, the first exposure being green shales with thin, quite ferruginous limestone partings, of the Niagara, which may go up to a shoulder, 790 A. T. on the north side of the hill, or even higher. On the south side they appear to

* This is used as a base for all other barometric determinations.

stop at 720 A. T., however, and on the first hill on the road south at 685 A. T. A southerly dip is thus indicated. At the latter point a little highly ferruginous limestone may represent the Corniferous, but it is very thin. Then above, nearly to the top of the hill are the Devonian black shales. But the very top is capped by loose slabs of a very fine grained hard compact sandstone, which I take to be the Berea grit at the bottom of the Carboniferous and Waverly series, about 980 A. T. This would make the Devonian here 130 feet or more thick. As we follow the railroad over the divide between Salt Lick creek and the Caney creek drainage, the first exposures of black shale are about 680 A. T., while the Waverly group appears to come in at about 820 feet A. T. This is about a mile south and the top of the hill is as high as before, 945 A. T. All the cuts on the north side of the divide are in black shale, but none are found over 850 A. T. When we descend into the valley of Caney creek, we find for about one-third of the way to the mouth, and down to an elevation of about 805 A. T., the hard Berea grit following us down and dipping in the same direction. Then the rest of the way to Caney creek is on black shale, although a little over half way down, at a point where marked side valley enters from the north, it seems as though the top of the black shale was suddenly thrown up. The dip of the black shale appears to be in general toward S. 40° E., and we see from the figures at a rate of something like 55 feet to the mile. When we leave Caney creek however and follow the valley of the Licking around to Raglands we soon find the hard band of the Berea grit down to the level of the railroad track, say 680 A. T., and dipping in an abnormal direction, S. 38° W. Less than two miles away three companies are putting down wells, a 56,000 gallon tank and several smaller ones are erected, numerous wells were being pumped and three machines were at work. The Mount Sterling Company have sold out to Guffey and Gailey, who have some 17 wells yielding, it is said up to 70 barrels a day apiece. Then there is the Yale Oil, Mining and Manufacturing Co., and the Licking Valley Oil and Gas Co. The superintendent of the latter, Mr. Craig, says that they have about 12 wells, most of which I saw. At the one upon which they were at work the surface river deposits were some 40 feet thick. Then came the blue shale, with occasionally hard beds one or two feet thick, of the Waverly. At the bottom, and in many of the other wells at 125 to 130 feet, is the hard bed which we saw on the side of the hill and take to represent the Berea grit. Then come the Devonian black shales, which were so conspicuous below it, and then, he says only a few feet below it, separated by "fireclay" the "bastard limestone," which is the oil rock, at 310 to 320 feet. Samples of a deeper well are preserved by Prof. Miller, where there may be more shale between the black shale and the oil rock. The wells deepen to the south and east rapidly from 225 and 260 to 302 and 320. At the latter depths are some of the most productive wells. On the south side of the big bend of the Licking, and two miles farther southeast close to the county line, they are 386 and 447 feet deep. This is near Yale.

The oil must come from the Clinton, or possibly at times from the Corniferous. The two rocks are exceedingly alike. Both frequently yield oil, but the Corniferous is poorly developed, and often absent in this county.

About five miles west-southwest of Raglands is a knob called Carrington's Rock, which rises to 1,396 feet A. T., and is capped by about 200 feet of the conglomerate which forms the base of the coal measures. This is about in the direction of the strike from Raglands, and we are thus able to infer quite closely how far below the base of the coal measure series (counting the Pottsville therein) this oil horizon will be. Its relation is indicated on the section.



SECTION FROM SALT LICK, KENTUCKY, THROUGH THE BATH COUNTY OIL-FIELD AND THE MORGAN COUNTY ANTICLINE.

Fig. 2.

In the Bath county region the general dip appears to be southeasterly, about 50 feet to the mile on the average, reckoning from the Berea grit 915 A. T., at Salt Lick, to the exposure at Raglands, where it is about 680 A. T., it is $235 \div 4.5 = 52$ feet per mile. Then there is a little secondary arch there or down fault between that and the Licking valley well. An arch might run N. 70° E., nearly parallel to the Morgan county anticlinal, with its crest a little north of Raglands, but there are not enough facts to locate it. The oil wells appear to be on the steeper slope of the subordinate arch. The oil as used in the State College at Lexington, proved to be a very good lubricant, and like limestone oils frequently, free from grit.

CONCLUSION.

The net result is that just north of Cannel City, the terminus of the Ohio & Kentucky Railroad, and about 27 miles by the road from the developed oil field in the south part of Bath county, within six miles of the railroad, is a well developed anticlinal, of just about the right size to serve as a good reservoir for gas and oil, and the prospects for striking oil and gas are as good as could be expected, short of actual development with the drill.

Of the 8,500 acres leased and controlled by you, 1,250 cover about four miles of the crest and flanks for a strip a quarter of a mile wide on each side of the anticlinal. This I should consider the cream, and should recommend beginning development in this region. The crest of the anticlinal may, however, differ in position somewhat at different depths, as is shown clearly enough by the diagram, Fig. 1, and I have located it only approximately. Careful record should be made of the strata as the drilling progresses, and subsequent work planned accordingly.

The relative proportions of oil and gas it is impossible to foresee. They may vary greatly in different beds. The utilization of the gas would require much heavier capital, as it would almost require a pipe line to Cincinnati. But if too much gas and too little oil in proportion was found on the crest of the anticlinal it would be more than likely that farther down the slope oil would be found.

Most of your land lies on the northwest side, which is also the steeper side of the anticlinal. While I consider this side quite as likely to be a good oil yielder as the other, I would recommend beginning exploration on the right fork of Whiteoak, where you control both sides, and first as nearly on the crest of the anticlinal as can be located. The extra risk of striking too much gas there, which might be used, however, for fuel in later operations, being to my mind compensated for by the less depth of exploration.

Moreover it will not be possible to strike the crest of the anticlinal for all depths at the first attempt. Then I should drill other wells up and down the valley, probably not more than a quarter of a mile from the first, depending somewhat on what was found in the first. A dozen wells should be enough to give a very good idea of the property, and if they turn out as well as I expect, put it in shape for production. If I am right in my section I do not believe it will be over a thousand feet at the center of the anticlinal to the Bath county oil horizon with a good chance of striking oil or gas in horizons above.

The section would be:

	Feet.	Total.
Rockcastle conglomerate (oil or gas)	150	150
Pennington green shales and coal	40	190
St. Louis limestone, Maxville of Ohio, Mountain of W. Va., fissure oil or gas possible	150	340
Waverly sandstone and shale; the Berea and Big Injun (oil sands) belong here, but the beds will probably be too fine grained to yield	350	690
Devonian black shale	200	890
Corniferous (Lower Devonian limestones), oil? perhaps absent entirely	10?	900
Upper Silurian shales (Niagara)	30	930
Clinton magnesian limestone, oil	30	960
Hudson series	600	1,560
Trenton (oil horizon.)		

It would be best, however, for safety, to adopt Prof. Miller's figures, which are maxima, and plan for a 2,500 foot well as a starter. If you wish I will order the Michigan Drug Co. to send you a sample case of bottles, such as they put up for me for work here in Michigan. The cost of a thousand foot well should be less than $1.00 a foot. The cost rises rapidly with the increased depth, and while you ought to get a 2,500 foot well for $5,000 it would be safer to allow $7,000. I should recommend advertising for bids at Lima. In this State, T. Percy now of Toledo, a man of means, and responsibility, has put down the deepest wells. J. J. Mason & Co., of Detroit, have also put down many deep wells, and J. P. Miller & Co., of Chicago, have put down a number over 2,000 feet deep.

I do not think it will be necessary or advisable in any case to put all the preliminary wells down so far as 2,000 feet, but advice as to the later wells can much better be given after the first.

I should suggest that some geologist like Prof. Miller be continually consulted during the progress of the wells.

I should suggest therefore as needed for working capital:

First well	$7,000
Eleven other wells	16,500
Pipe line to Cannel City, pumping plant and incidentals. For these estimates can be obtained from the National Supply Co. Much will depend on what is found, but I should not want to plan for less than	20,000
Minimum total	$43,500

I should also urge that provision be made so that if there is a profit ahead in it, a pipe line could be run to the Bath oil field, in case a refinery is located there, or so that you could build your own refinery. A gas pipe line to Cincinnati is also among the possibilities, and for these purposes it might ultimately be well to provide $75,000 more, even before you were prepared to pay for the same out of profits.

Undoubtedly in case of success you will want more than a dozen wells, but those you will be able to take out of proceeds and charge to running expenses.

Respectfully submitted,
ALFRED C. LANE.

Office of the State Geologist, Lansing, Michigan.

Note.—Maps accompanying the report are not reproduced.

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